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THE ECOLOGICAL EFFECTS OF BURNING, MOWING, AND PLOWING ON GROUND-INHABITING SPIDERS (ARANEAE) IN AN OLD-FIELD ECOSYSTEM

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ABSTRACT

Cursorial spiders were studied in northeast Missouri from April-November 1980 in annually manipulated old-fields, in fields undergoing succession from manipulations, and a control field. Manipulations included burning, mowing, and plowing. Eleven cursorial families were collected in the study. Pitfall traps were used as the collecting device. Spider communities were compared using Bray-Curtis similarity indices. Seasonal and monthly spider and plant diversities were calculated using the Shannon Index. Spider diversity was correlated with plant diversity during May. The relative abundance of five spider species was correlated with the importance value of several plant species.

INTRODUCTION

Some of the current land management practices include burning, mowing, and plowing. These practices along with natural disturbances often result in changes in abundance, species composition, and diversity within both the plant and animal communities (Lowrie 1942). Ecosystem disturbances appear to be important factors in the evolution of plant and animal species (Denslow 1980, Connell and Slayter 1976, and Pickett 1976). Since plants are important to arthropods from the standpoint of food and other factors any natural or man-made disturbance (e.g. burning, mowing, and plowing) in the plant community may significantly alter the arthropod community (Lowrie 1942). Relatively small differences in habitat structure have been shown to affect significantly the abundance and type of spiders present (Duffey 1978). Many workers have reported associations between arthropod and plant diversity and succession (Almquist 1973, Muma 1973, Drew 1967, Duffey 1962, Chew 1961, Kajak 1960, and Elliot 1930 cited by Bultman et al., 1982; Murdoch et al., 1972; Riechert and Reeder 1972; Lowrie 1948, 1942). Spider diversity and abundance have been correlated with the physical structure of the litter (Hagstrum 1970, Berry 1967, and Lowrie 1948 cited by Bultman et al., 1982; Uetz 1979; Uetz 1975, Jocque 1973 cited by Uetz 1976).

Extensive reviews on prairie fire ecology may be found in Wright and Bailey (1980) and Hulbert (1969). Studies on the effects of cultivation and mowing have been reported by Duffey (1978), and Kajak et al. (1971). Diversity theories and indices have been reviewed and modified by many workers (Berry 1967 cited by Bultman et al., 1982, Pianka 1978, Uetz 1974, Huhta 1971, Goodall 1968, Lloyd

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et al., 1968, Pielou 1966a, 1966b, and Lowrie 1948). Reviews concerning the use of pitfall traps may be found in Merrett (1976), Uetz and Unzicker (1976), Gist and Crossley (1973), Duffey (1972), Huhta (1971), Southwood (1966), and Greenslade (1964).

Specifically, the objectives of this study were to: 1) identify the cursorial spider fauna in fields which were manipulated (burned, plowed, and mowed) annually for the past four years, fields manipulated four years ago and undergoing succession, and a control field, 2) determine the active density, diversity, and similarity of cursorial spider populations in these fields, 3) determine the effects of vegetation on spider distribution, and 4) compare the capture efficiency of white and clear pittraps (reported elsewhere).

METHODS

Spiders were sampled in an 8.1 hectare area located approximately 2 kilometers south of Kirksville in northeast Missouri. The area lay fallow for approximately 20 years before the land management study originated. Seven fields employing three common agricultural land management techniques: burning, mowing, and plowing were used in the study. Fields were subdivided into four quadrats measuring approximately 30 m by 40 m each. To reduce edge effect a buffer zone at least 9 m in width surrounded each field. Experimental design involved the administration of one treatment per field: annually for one quadrat, every fifth year for a second quadrat, and every 10th and 20th year for the third and fourth quadrats respectively (Figure 1).

Field manipulations were started in 1976. At that time two fields (all eight quadrats) were burned, two fields were mowed, and two fields plowed. Manipulated fields were mowed and plowed in the fall, and burning treatments were conducted in the spring. Area II fields served as duplicates of Area I to increase the sample size. The seventh field was left untreated as a control. Samples for this study were taken from quadrats that were manipulated annually for the past four years, quadrats manipulated four years ago and undergoing succession, and a control field which had been fallow for 20 years.

Pitfall trapping for cursorial spiders was conducted from April to November 1980. Six traps, 3 clear and 3 white, were placed approximately 10 m apart in each quadrat. A total of 42 white and 42 clear traps were used in the study. The initial trap color arrangement within each quadrat was random. Thereafter the color arrangement and trap location were constant throughout the study. Traps were placed in the ground for 7-day intervals approximately every 3 weeks. A small amount of ethylene glycol was placed in each trap as a preservative. Clear and white trap data were combined for the spider analyses in this paper.

Vegetation data, including frequency, density, cover, grass mat depth, and species, were collected for area I quadrats. Three random one-square meter samples from each quadrat were taken during the months of May, July, and September. Grass mat depth was also recorded for each sample. Vegetation in Areas I and II appeared to be similar. Vegetation samples were not taken, however, from Area II because of time limitations.

Spider identifications were made to the species level for adults, and family level for juveniles. Several non-cursorial species were identified only to family.

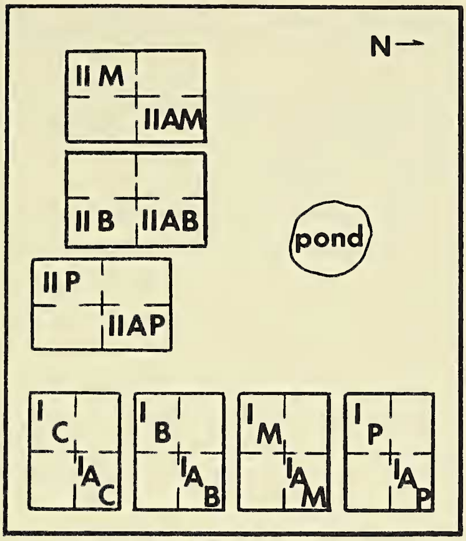

Fig. 1.—Map of study site using field and quadrat abbreviations. Abbreviations: I-area one fields, II-area two fields. Four year succession quadrats: burned-IB,IIB; mowed-IM,IIM; plowed-IP,IIP. Annually manipulated quadrats: burned-IAB,IIAB; mowed-IAM,IIAM; plowed-IAP,IIAP. Control quadrats-IAC,IC (AC used to distinguish between control fields). (1 cm = 30 m)

Comparisons of active densities were made for selected species between annually treated quadrats and their succession counterparts. The Bray-Curtis similarity index (Huhta 1979) was used in community comparisons between habitats which had received different physical treatments, and between communities undergoing succession from those physical treatments. The number of guilds and their percent composition was compared with the study habitats.

Spider diversity using the Shannon (1948) Index was calculated. Previous studies dealing with pitfall trapping of cursorial spiders have also used the Shannon Index (Jocque 1973, Uetz 1975, 1976, 1979a, 1979b, Pielou 1966 cited by Bultman et al., 1982). Diversity analyses were made for each quadrat using data for the trapping season. Diversity indices between quadrats were tested for significant differences with a t-test proposed by Hutcheson (1970 cited by Zar 1974). Trap dates were then separated into three groups which corresponded closely with the vegetation sampling dates. Diversity analyses were then made for each quadrat using the grouped data.

Importance values for each plant species were calculated by adding relative density, relative frequency, and relative dominance values for each species (Cox 1980). Linear correlation analyses were run using the importance values for plant species and the number of adult spiders captured in selected species. Monthly plant diversity was also calculated for the samples taken in area I using the Shannon Index. Hutcheson's test was used to determine significant differences in plant diversity.

RESULTS AND DISCUSSION

Representatives of thirteen spider families, eleven of which are considered cursorial or vagrant web builders, were captured. Forty-one genera with sixty-three species represented the eleven families, with a total of 1,989 adults and 2,945 juveniles (Table 1).

Chi-square analyses indicated that significant differences existed in the numbers of adult cursorial spiders captured in many of the quadrats. The annually plowed quadrats (area I and II) exhibited significantly fewer spiders than all quadrats except the annually mowed (area I) quadrat. The differences were not significant for these two quadrats (Table 2). The number of adult spiders captured in other annually manipulated quadrats was usually significantly less than the numbers captured in their succession counterparts. However, two exceptions were observed: higher numbers captured in the annually mowed quadrat as compared to mowed quadrat in area II, and no difference in the numbers captured between annually burned and burned quadrats in area I. Three quadrats exhibited significantly higher numbers of spiders than did the control quadrats. These quadrats included: plowed (area I), annually mowed (area II), and burned (area II). Other succession quadrats also exhibited higher numbers, but they were not statistically different, as compared to the control quadrats.

Nine cursorial species representing three families accounted for approximately 65% of the adults captured. The species were: *Neoantistea agilis, Hahnia ononidum, Schizocosa saltatrix, Schizocosa retrorsa, Schizocosa bilineata, Schizocosa avida, Pardosa saxatilis, Callilepis pluto, Zelotes laccus.* The two species with the highest active densities for the trapping season were *S. avida* and *Z. laccus* respectively.

Guild composition analysis revealed wolf spiders as the major guild in all quadrats except the annually plowed area I quadrat where running spiders predominated, and in a control quadrat where vagrant spiders were most abundant. Crab and jumping spiders composed the highest percent guild composition in the annually mowed and annually burned, area I, quadrats respectively (Figure 2).

Bray-Curtis analyses resulted in similarity indices between annually plowed quadrats and plowed quadrats of 0.36 and 0.48. Similarity was higher (approximately 0.65) between annually mowed and annually burned quadrats and their succession counterparts (Table 3). As expected, annually manipulated quadrats showed less similarity to the controls than did the succession quadrats. Bray-Curtis similarity indices indicated the mowed and burned area II quadrats were the most similar in species composition with a value of 0.79. Both of the annually plowed quadrats exhibited low degrees of similarity with other quadrats. Similarity indices were calculated for quadrats between treatment types within area I and area II (i.e. areas I and II were not compared). Those quadrats having similarity indices greater than 0.60 are included in Table 3.

Similarity indices were also calculated for the major guilds. Quadrats exhibiting the highest similarity for the running spiders were mowed and annually burned quadrats in area II with an index of 0.80. Wolf spiders had the highest similarity in the mowed and burned quadrats (area II) with a value of 0.85. Their lowest similarity was between the annually plowed quadrats of areas I and II, with a value of 0.22. Wolf spiders in both annually plowed quadrats exhibited low degrees of similarity with other quadrats. Vagrant spider populations were found to be most similar in the annually mowed and burned area II quadrats with an index of 0.94. Jumping spiders were found to be most similar in the annually mowed and annually burned area II quadrats with a value of 0.72.

The number of species captured in each quadrat ranged from 13 to 31 with an average of 23 species. The highest spider diversity for the season was found

Table 1.—Spider species represented in the study. Asterisk denotes web-building spiders known to leave their webs when foraging for prey. (Ann = Annual, Suc = Succession, I and II = areas I and II)

	Adults Captured in Quadrats						
	Plowed		Mowed		Burned		Control
	Ann I,II	Suc I,II	Ann I,II	Suc I,II	Ann I,II	Suc I,II	I,II
Wolf spiders							
Lycosidae							
Lycosa avara (Keyser.)	0, 0	0, 0	0, 1	0, 0	0, 0	0, 0	6, 2
L. punctulata (Hentz)	2, 0	1, 0	0, 0	1, 0	0, 0	2, 0	3, 3
L. rabida Walck.	0, 0	3, 0	0, 0	1, 0	0, 0	1, 0	0, 1
Lycosa sp.	0, 0	2, 0	2, 0	2, 2	2, 0	0, 3	1, 0
Pardosa saxatillis (Hentz)	0,10	27,21	3, 1	3, 5	13,18	2, 5	0, 1
Pirata hiteorum Wallace and Exline	0, 0	0, 0	0, 0	0, 1	2, 0	2, 0	4, 0
P. minutus Emerton	0, 0	3, 6	0, 3	1, 4	2, 0	3, 3	3, 2
Schizocosa avida (Walck.)	3,14	20,30	10,44	24,16	47,46	32,60	11,11
S. bilineata (Emerton)	1, 0	2,17	8,21	21,15	1, 1	17,22	21,14
S. retrorsa (Banks)	0, 5	6, 2	13,16	1, 6	14,14	3, 6	7, 7
S. saltatrix (Hentz)	2, 0	24, 9	0, 3	5, 4	1, 4	2, 6	7, 3
Schizocosa sp.	0, 0	0, 0	0, 0	0, 1	0, 0	0, 0	0, 0
Lycosidae sp.	0, 3	0, 0	0, 0	3, 0	0, 3	0, 1	4, 1
Running spiders							
Clubionidae							
Castianeira descripta (Hentz)	1, 0	3, 0	0, 0	0, 0	0, 0	1, 1	0, 0
C. gertschi Kaston	0, 1	2, 0	0, 0	1, 0	0, 0	0, 0	0, 0
C. longipalpus (Hentz)	0, 0	1, 1	0, 0	0, 0	0, 0	0, 0	0, 0
C. variata Gertsch	1, 0	1, 0	0, 0	0, 0	0, 0	0, 1	1, 0
Clubiona johnsoni Gertsch	0, 0	1, 0	0, 0	1, 0	0, 0	0, 0	1, 0
C. mixta Emerton	0, 0	0, 0	0, 0	0, 1	0, 0	0, 0	0, 0
Scotinella similis (Banks)	0, 0	0, 0	0, 1	0, 0	0, 0	0, 0	0, 0
Scotinella fratella (Gertsch)	1, 0	1, 1	0, 0	0, 0	0, 0	0, 0	0, 0
Clubionidae sp.	0, 0	1, 0	0, 0	0, 0	0, 1	0, 0	0, 0
Gnaphosidae							
Callilepis pluto Banks	9,11	1, 2	2, 2	0, 9	4,11	1, 5	2, 0
Drassylus depressus (Emerton)	2, 1	4, 3	4, 2	2, 0	6, 2	0, 1	2, 0
D. fallens Cham.	0, 0	2, 1	0, 0	0, 0	0, 0	0, 0	0, 0
D. nannellus (Chamber. and Gertsch)	0, 0	1, 0	0, 1	0, 0	0, 0	1, 0	4, 1
D. rufulus (Banks)	1, 0	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0
Drassylus sp.	0, 0	0, 0	0, 1	0, 0	0, 0	1, 0	0, 1
Haplodrassus signifer Koch	0, 0	0, 0	0, 0	1, 0	0, 0	0, 0	0, 1
Micaria elizabethae (Gertsch)	0, 0	3, 5	0, 6	4, 3	0, 3	3, 9	2, 0
Sergiolus variegatus (Hentz)	0, 0	0, 0	0, 0	0, 2	1, 0	1, 1	1, 2
Zelotes hentzi Barrows	0, 0	0, 0	0, 2	0, 1	0, 1	2, 0	0, 0
Z. inheritus Kaston	0, 0	0, 0	1, 1	0, 0	0, 0	1, 0	0, 0
Z. laccus (Barrows)	0, 3	21,18	7,33	28,23	11,10	35,40	23,21
Gnaphosidae sp.	1, 0	3, 0	0, 1	1, 2	3, 1	0, 2	2, 0
Crab spiders							
Philodromidae							
Thanatus sp.	1, 0	4, 3	4, 1	6, 2	3, 5	9, 4	9, 6
Thomisidae							
Xysticus sp.	2, 5	22,27	16,18	24, 6	17,15	11,10	12,16
Thomisidae sp.	0, 2	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0
Jumping Spiders							
Salticidae							
Agassa cyanea (Hentz)	0, 0	0, 0	1, 0	0, 0	0, 0	1, 0	0, 0
Corythalia delicatula (Gertsch & Mulaik)	0, 0	0, 0	2, 0	1, 0	0, 0	0, 0	1, 0

Table 1.—Continued.

Eris aurantia (Lucas)	0, 0	1, 1	0, 2	0, 1	4, 2	2, 1	0, 1
Evarchi hoyi (Peckham)	0, 0	0, 2	0, 3	2, 1	0, 0	0, 1	3, 1
Marpissa mucosa (Clerck)	0, 0	1, 0	0, 0	0, 0	0, 0	0, 0	1, 0
Metaphidippus canadensis (Banks)	0, 1	0, 0	0, 0	2, 2	0, 0	1, 0	3, 0
M. galathea (Walck.)	0, 0	0, 0	0, 1	1, 0	1, 1	1, 0	0, 2
Pellenes coecatus (Hentz)	0, 2	0, 1	1, 0	0, 0	2, 1	0, 0	0, 0
Pellenes sp.	1, 0	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0
Phidippus clarus (Keyser.)	0, 0	1, 0	1, 0	0, 0	2, 0	1, 0	0, 0
P. mc cooki (Peckham)	0, 0	1, 1	0, 0	0, 0	0, 0	0, 1	1, 0
P. princeps (Peckham)	0, 0	0, 0	0, 1	1, 0	0, 1	0, 0	1, 2
Sarinda hentzi Banks	0, 0	0, 1	0, 0	1, 2	0, 0	0, 0	0, 0
Sitticus cursor Barrows	0, 0	0, 2	1, 4	3, 3	6, 3	3, 6	2, 1
S. striatus Emerton	0, 0	0, 0	0, 0	0, 0	0, 0	1, 0	0, 1
Talavera minuta (Banks)	0, 0	0, 1	3, 0	2, 2	6, 1	5, 1	0, 2
Salticidae sp.	0, 0	0, 1	0, 0	1, 0	0, 0	0, 0	0, 0
Vagrant spiders							
Agelenidae							
*Cicurina cavealis** (Bishop & Crosby)	5, 4	2, 3	2, 0	0, 0	1, 4	1, 0	0, 0
*C. ludoviciana** (Simon)	0, 0	0, 1	0, 0	0, 0	0, 0	0, 0	0, 0
Hahniidae							
*H. ononidum** (Simon)	0, 0	0, 2	2, 0	2, 0	0, 0	1, 0	25,35
*Neoantistea agilis** (Keyser.)	0, 4	13,11	5, 8	6,13	3, 2	7, 6	0, 3
Other guilds							
Antrodiatidae							
Antrodiaetus stygius (Coyle)	6, 0	2, 0	0, 2	0, 0	0, 1	0, 1	0, 0
Oxyopidae							
Oxyopes salticus (Hentz)	0, 1	3, 1	2, 0	4, 6	1, 4	0, 3	0, 0
Mimetidae							
Mimetus epeiroides Emerton	0, 0	0, 0	0, 0	1, 0	0, 0	0, 0	0, 0
Ero sp.	0, 0	0, 0	0, 0	0, 0	0, 0	0, 0	1, 0
Web-builders							
Araneidae	30,45	23,36	34,35	28,37	44,34	30,28	46,37
Agelenidae							
Agelenopsis kastoni Chamber. & Ivie	0, 0	0, 1	0, 0	0, 0	0, 0	0, 0	0, 0
Agelenopsis sp.	0, 0	0, 1	0, 0	0, 0	0, 0	0, 0	0, 0
Agelenidae sp.	0, 0	0, 0	0, 0	0, 0	1, 0	0, 0	0, 0
Dictynidae	15,37	8, 1	9, 4	4, 1	15, 0	7, 2	0, 1

in the plowed quadrat of area I with an index of 2.720. The lowest diversity calculated was 2.203 and was in the annually plowed quadrat of area II (Table 4). Differences in diversity values were tested between quadrats. The diversity in the plowed quadrat of area I was significantly higher than the diversities in the annually plowed, annually burned, burned, and control quadrats of area I. The area II plowed quadrat was significantly higher in diversity than the annually mowed, and burned quadrats of area II.

Community complexity and diversity usually increase during early and mid-succession seral stages. Arthropods generally increase in number as succession progresses toward a climax state (Bultman et al. 1982). The succession quadrats in this study should, therefore, be higher in diversity than the annually manipulated quadrats. This was observed for the annually plowed (area I and II) and the annually mowed (area II) quadrats when they were compared to their succession counterparts. The annual burn quadrats (areas I and II and the area I mowed quadrat exhibited low diversity values in the spring, but the diversities rapidly

Table 2.—Quadrats exhibiting significant differences between seasonal pitfall catches of spiders. Asterisks denote: * p<0.05, ** p<0.01, *** p<0.001.

Quadrats	Adults captured		Chi-square value
IAP I P	39	183	92.112***
IIAP II P	67	172	42.255***
IAP IAM	39	90	19.379***
IIAP IIAM	67	178	49.388***
IAP I M	39	156	69.005***
IIAP II M	67	130	19.513***
IAP IAB	39	152	65.675***
IIAP IIAB	67	155	34.094***
IAP I B	39	153	66.505***
IIAP II B	67	197	63.034***
IAP IAC	39	162	74.049***
IIAP IAC	67	162	38.585***
IAP I C	39	139	55.061***
IIAP I C	67	139	24.471***
I P IAM	183	90	31.004***
II P II M	172	130	5.566*
I P I C	183	139	5.742*
IAM I M	90	156	17.174***
IIAM II M	178	130	7.172**
IAM IAB	90	152	15.376***
IAM I B	90	153	15.818***
IAM IAC	90	162	20.003***
IAM I C	90	139	10.061**
IIAM I C	178	139	4.555*
II M II B	130	197	13.321***
IIAB II B	155	197	4.775*
II B I C	197	139	9.670**

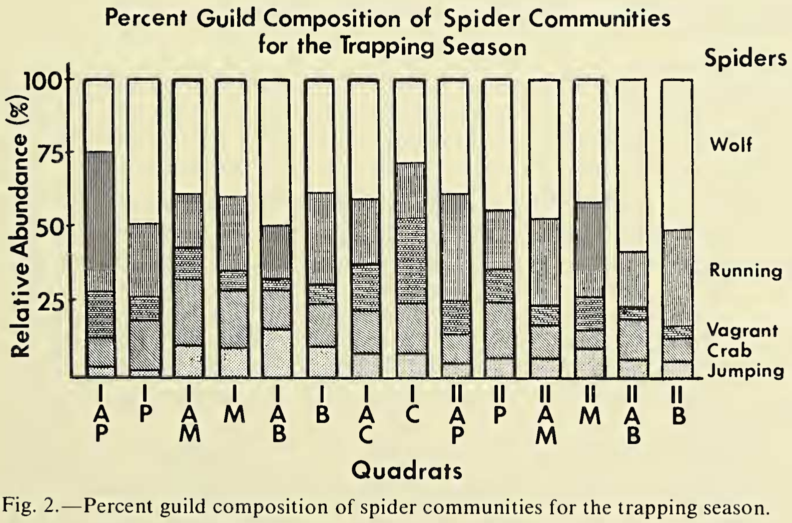

Fig. 2.—Percent guild composition of spider communities for the trapping season.

Table 3.—Bray-Curtis similarity values for the cursorial spider community for the trapping season (0.00 no similarity, 1.00 maximum similarity).

Quadrat comparisons	Bray-Curtis values <0.60	Bray-Curtis values >0.60	Quadrat comparisons	Bray-Curtis values >0.60
IAP I P	0.36		II M II B	0.79
IIAP II P	0.48		IIAM II B	0.74
IAP I C	0.23		II P II B	0.72
IIAP I C	0.36		IAM IAB	0.70
I P I C	0.50		II P II M	0.68
II P I C	0.56		IIAM IIAB	0.67
			II P IIAM	0.66
IAM I M		0.61	II P IIAB	0.66
IIAM II M		0.68	I M I B	0.66
IAM I C	0.57		II M IIAB	0.66
IIAM I C		0.66	IIAP IIAB	0.63
I M I C		0.67	I P IAB	0.63
II M I C	0.57		I P I M	0.62
			IAM I B	0.61
IAB I B		0.64		
IIAB II B		0.69		
IAB I C	0.53			
IIAB I C	0.54			
I B I C		0.70		
II B I C		0.60		

increased. By July these diversities were similar to the diversities observed for their succession counterparts, and also of the controls. Hence no significant differences in diversity were observed for these quadrats in the overall trapping season.

Shannon diversity indices were also calculated for vegetation data collected in area I (Table 5). Previous studies have shown increased diversity in disturbed grasslands and old-field habitats for the first one to four years (Hessing et al. 1981 and Bazzaz 1975). Diversity then decreases somewhat as grasses become the dominant species of the habitat. Increases in diversity are again observed after

Table 4.—Shannon diversity and J values for spiders in each quadrat for the trapping season.

Quadrat	Number of species captured	Number of adults captured	Diversity value	J component of evenness
IAP	14	36	2.305	0.873
I P	31	157	2.720	0.792
IAM	19	70	2.604	0.884
I M	29	126	2.601	0.773
IAB	21	132	2.349	0.771
I B	28	133	2.434	0.730
IAC	26	141	2.696	0.827
I C	23	117	2.351	0.750
IIAP	13	60	2.203	0.859
II P	26	144	2.577	0.791
IIAM	24	160	2.326	0.732
II M	23	123	2.663	0.849
IIAB	24	136	2.375	0.747
II B	23	185	2.240	0.714

Table 5.—Shannon diversity and J evenness values for vegetation sampled in area I.

Quadrat	Number of plant species	Diversity value	J component of evenness
May			
IAP	14	0.380	0.144
I P	29	2.649	0.787
IAM	24	1.390	0.437
I M	22	2.295	0.743
IAB	19	0.880	0.299
I B	20	2.207	0.737
IAC	10	1.419	0.616
I C	13	1.653	0.645
July			
IAP	25	0.992	0.308
I P	32	2.878	0.831
IAM	27	2.475	0.735
I M	31	2.612	0.761
IAB	19	0.715	0.243
I B	24	2.296	0.722
IAC	14	1.700	0.644
I C	19	2.105	0.715
September			
IAP	22	1.194	0.386
I P	34	2.965	0.841
IAM	31	2.812	0.819
I M	32	2.859	0.825
IAB	27	1.618	0.491
I B	30	2.753	0.809
IAC	16	2.034	0.734
I C	21	2.289	0.752

woody plants and shrubs become established in the community. This second increase in diversity is initially rapid and then continues at a slower rate as succession continues toward a climax state. In this study the most diverse vegetation was observed during May in the plowed quadrat with a value of 2.649. This quadrat also had the highest diversities in July and September. July and September diversity values increased for most of the other quadrats. The diversity of the vegetation in the succession quadrats was higher throughout the season than the diversity of the control. Two quadrats, annually plowed and annually burned exhibited lower vegetation diversities than the control did throughout the season. However the diversity in the annually mowed quadrat was lower than the control's diversity in May, then increased, and was higher than the control's diversities in July and September.

Uetz (1975) found no relationship between cursorial spider and vegetation diversity in a forest. However he observed significant positive correlations between spider diversity and litter depth. Linear correlation analysis showed a significant positive correlation ($r = 0.747$, $p < 0.05$, d.f. = 6) between the vegetation diversity and spider diversity observed in May. A negative correlation was observed between vegetation and spider diversities in all quadrats for the overall season. This correlation was significant in only three quadrats: mowed ($r = -0.864$), annually burned ($r = -0.713$), and one control ($r = -0.726$) ($p < 0.05$, d.f. = 6 in each case). This was a result of the summer peak in spider abundance and diversity followed by a decline, whereas the plant abundance and diversity continued to increase throughout the season. No correlations were observed between spider diversity and grass mat depth.

Linear correlation analyses were made using importance values of plant species, and the number of spiders captured. These calculations were made using the eight quadrats from area I. Thirty-four significant correlations were observed between plant importance and the number of hahniid and lycosid spiders captured. Twenty-six correlations were observed in May, and eight in July (Table 6). Most of the correlations occurred in the annually plowed quadrat of area I. No correlations were observed in September. This was probably a result of the decline in spider abundance in the fall. Many of the correlations observed were significant because the plant species occurred in only one quadrat or its importance value was highest in that quadrat, and the number of spiders captured was highest in that particular quadrat. The vegetation in the quadrats exhibiting correlations may be characteristic of a particular habitat in which the spiders live. Whether or not the spiders were actually interacting with the plants cannot be determined from the data.

Hahnia ononidum was positively correlated with *Phleum pratense* and *Agrimonia gryposepala* and negatively correlated with *Prunella vulgaris*. *Neoantistea agilis* was positively correlated with nine plants. Five of these plants occurred only in the plowed quadrat (area I) where the active density of *N. agilis* was highest. The plants were: *Antennaria neglecta, Astor novae-angeliae, Potentilla simplex, Solidago graminofolia, Ulmus americana.* The four remaining plants: *Agrostis alba, Cerastium vulgatum, Chrysanthemum leucanthemum,* and *Erigeron strigosus,* exhibited high importance values in IP, and lower importance values in other quadrats.

Two wolf spiders were positively correlated with plants in May. *Pardosa saxatilis* was positively correlated in the annually plowed quadrat (area I) with seven plant species: *Agrostis alba, Antennaria neglecta, Astor novae-angeliae, Panicum lanuginosum, Potentilla simplex, Prunella vulgaris,* and *Ulmus americana. Schizocosa avida* was positively correlated with only one plant, *Astor* sp., during May. This correlation was observed in seven quadrats. *Schizocosa saltatrix* was correlated with six plant species during May. The species were: *Agrostis alba, Antennaria neglecta, Astor novae-angeliae, Potentilla simplex, Ulmus americana,* and *Solidago graminofolia.* The first four species were also correlated with *P. saxatilis* and *N. agilis.*

Significant correlations in July for spiders and plants were observed only in wolf spiders. *Pardosa saxatilis* continued to be correlated in the annually plowed area I quadrat with the importance values of *Panicum lanuginosum, Astor novae-angeliae,* and *Potentilla simplex.* It was also found to be correlated with *Solidago* sp. and *Composite* sp. The latter species was not observed in the May samples. However, *Solidago* sp. was present in both May and July. Whether or not the spider is truly correlated with this species is questionable. *Schizocosa avida* in July was positively correlated with *Phleum pratense* and *Veronia baldwinii. Astor* sp. was no longer significantly correlated with *S. avida* although it was still present in most of the quadrats. *Schizocosa bilineata* was also found to be correlated in several quadrats with *Phleum pratense* in July.

In this study the spider and flora communities found in fields which were plowed annually were quite different from those communities found in fields which were mowed and burned annually. Although some cursorial spiders appeared to be

Table 6.—Significant correlation coefficients from spider-plant linear correlation analyses. Asterisk denotes $p<0.05$, d.f. = 6.

Month	Plant Species	Spider Species	Correlation Coefficient
May	*Phleum pratense* L.	*Hahnia ononidum*	0.802*
May	*Agrimonia gryposepala* Wallr.	*H. ononidum*	0.919*
May	*Prunella vulgaris* L.	*H. ononidum*	−0.822*
May	*Agrostis alba* L.	*Neoantistea agilis*	0.807*
May	*Antennaria neglecta* Greene	*N. agilis*	0.764*
May	*Aster novae-angeliae* L.	*N. agilis*	0.764*
May	*Cerastium vulgare* L.	*N. agilis*	0.846*
May	*Chrysanthemum leucanthemum* L.	*N. agilis*	0.773*
May	*Erigeron strigosus* Muhl.	*N. agilis*	0.769*
May	*Potentilla simplex* Michx.	*N. agilis*	0.764*
May	*Solidago graminofolia* (L.) Salisb.	*N. agilis*	0.764*
May	*Ulmus americana* L.	*N. agilis*	0.764*
May	*Agrostis alba* L.	*Paradosa saxatilis*	0.944*
May	*Panicum lanuginosum* Ell.	*P. saxatilis*	0.794*
May	*Antennaria neglecta* Greene	*P. saxatilis*	0.956*
May	*Aster novae-angeliae* L.	*P. saxatilis*	0.956*
May	*Potentilla simplex* Michx.	*P. saxatilis*	0.956*
May	*Prunella vulgaris* L.	*P. saxatilis*	0.709*
May	*Ulmus americana* L.	*P. saxatilis*	0.956*
May	*Aster* sp.	*Schizocosa avida*	0.794*
May	*Agrostis alba* L.	*S. saltatrix*	0.934*
May	*Antennaria neglecta* Greene	*S. saltatrix*	0.973*
May	*Aster novae-angeliae*L	*S. saltatrix*	0.973*
May	*Potentilla simplex* Michx.	*S. saltatrix*	0.973*
May	*Solidago graminifolia* (L) Salisb.	*S. saltatrix*	0.973*
May	*Ulmus americana* L.	*S. saltatrix*	0.973*
July	*Panicum lanuginosum* Ell.	*Pardosa saxatilis*	0.750*
July	*Aster novae-angeliae* L.	*S. saltatrix*	0.798*
July	*Potentilla simplex* Michx.	*P. saxatilis*	0.798*
July	*Solidago* sp.	*P. saxatilis*	0.798*
July	*Composite* sp.	*P. saxatilis*	0.798*
July	*Veronia baldwinii* Torr.	*Schizocosa avida*	0.811*
July	*Phleum pratense* L.	*S. avida*	0.708*
July	*Phleum pratense* L.	*S. bilineata*	0.708*

correlated with the presence of certain plants it should not be concluded that there is a causal relationship. More study is needed in the area of spider-plant relationships. Annual plowing results in reduced spider and vegetation diversity. Mowing and burning treatments that are annually or periodically administered and periodic plowing may increase spider and vegetation diversity above that of a fallow control field.

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